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Essay

A changing climate for seagrass conservation?

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Tropical coral reefs are threatened and in decline, and their future is highly uncertain. With increasing rates of climate change and rising global temperatures, people looking to coral reefs for food and income may increasingly have to rely on resources from other habitats. Efforts to protect and conserve the coral reefs we have left are critical for a suite of economic, ecological, cultural and intrinsic reasons, but there is also an urgent need to take heed of the future scenarios from coral reefs and broaden the focus of tropical marine conservation. Seagrass meadows in particular are becoming ever more important for people and planet as coral reef health declines, but these systems are also globally under stronger anthropogenic threat. We need to increase and reprioritize our conservation efforts and use our limited conservation resources in a more targeted manner in order to attain sustainable systems. For seagrass, there are practicable conservation opportunities to develop sustainable ways to respond to increased resource use. Targeted action now could restore and protect seagrass meadows to maintain the many ecosystem services they provide.

Seagrass meadows are of fundamental importance to humanity: they support global fisheries production, play a vital role in our global carbon cycle and act as important bio-filters in our coastal ecosystems [1–3]. Seagrass meadows are globally expansive but are subject to growing levels of degradation, principally due to local water quality and physical disturbance problems [4]. In the tropics, for instance in Indonesia, there is increasing evidence that a widespread lack of management of these ecosystems is exacerbating these problems [5]. Yet, tropical seagrass meadows remain in the shadow of their more illustrious neighbours, coral reefs, in terms of media attention, research and conservation funding (Figure 1). Despite supporting charismatic species such as dugong, green turtle and seahorses, these habitats are often characterized as being generally less colorful and less teeming with life [6].

The future of corals reefs is becoming increasingly uncertain with serious consequences for the ecosystem services that they provide. As climate changes and reefs degrade, people looking to coral reefs for food and income may increasingly have to rely on other nearby habitats such as seagrass meadows. For a suite of economic, ecological, cultural and intrinsic reasons, we need to ensure a pathway for coral reef survival into the future, but there is also an urgent need to broaden the focus of tropical marine conservation. Tropical marine conservation can no longer afford to take a blinkered view that focuses exclusively on coral reefs. Tropical seagrasses are becoming ever more important for people and planet, and increasing resources also need to be put into supporting their long-term conservation.

Global decline of coral reefs

Coral reefs are undergoing widespread decline [7]. The resources they supply are also in decline, as these ecosystems become increasingly dominated by low-complexity (e.g. less branching) corals, sponges, algal communities or mobile rubble that harbour fewer animal species and individuals [8]. A coral-reef disaster is unfolding in front of us, and its full consequences are far from being realised. Climate-induced impacts on Coral reefs are so severe as to necessitate risk planning initiatives to determine reef locations globally that, in the absence of other impacts, are likely to have a higher chance of surviving projected climate change [9].

Coral reef conservation is possible, and researchers have recently argued the case for the value of local management in improving reef resilience [10]. But the effectiveness of reef conservation is diminishing with every bleaching event [7]. Unfortunately, dire predictions and calls for action over the last few decades have largely failed to lead to positive change [11–14]. We are now seeing increasing evidence of negative reef accretion rates in places previously considered pristine [15]. Coral-reef loss is a global problem driven by a changing climate, and the consequential declines in coral reef productivity are likely to have profound impacts upon associated coral reef fisheries [16]. Given the poor recovery of many reef systems following climate [14] and other impacts, scientists have grappled with the response to restore coral reefs using active intervention [14,17]. But we now know that reef restoration is also unlikely to be economically viable at any meaningful scale [18]. Even so, increasing levels of funding continue to support ever more desperate reef restoration and preservation projects [19].

We should not give up on coral-reef conservation, as there are glimmers of hope [20] and our understanding of the benefits of local management for reef resilience increases [10]. But given the unfolding coral reef disaster, it is time the tropical marine conservation community broadened

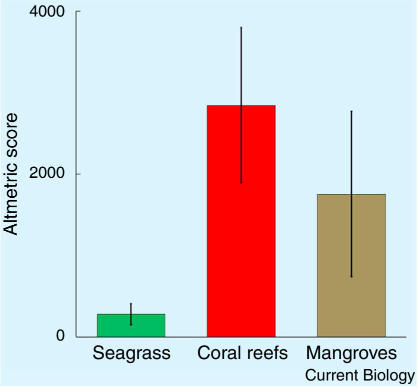

Figure 1. The seagrass media-attention crisis.
The mean (±SD) global media coverage (as measured by Altmetric score) of the 10 top research articles listed by Altmetric for seagrass, coral reefs and mangroves (search conducted using dimensions.ie).

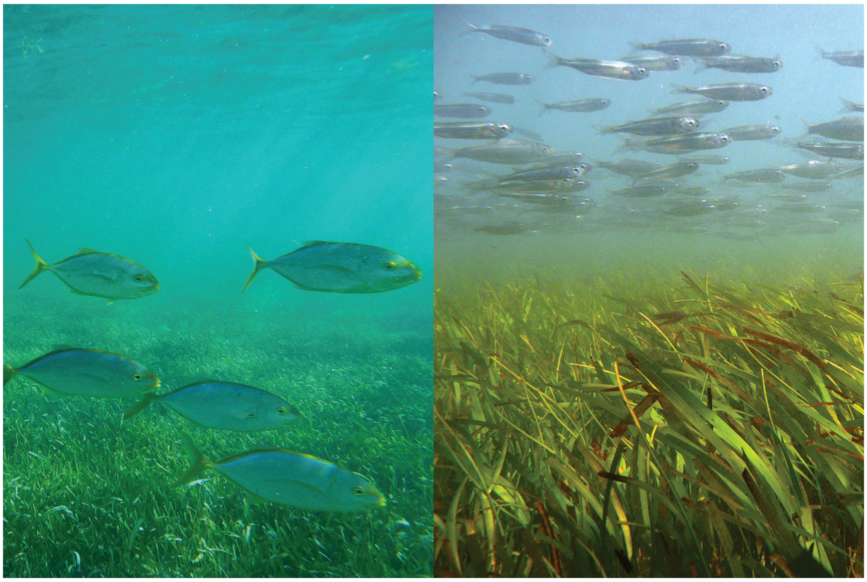

Figure 2. Healthy seagrass leads to healthy fisheries.
When healthy and well managed, seagrass meadows can support highly productive fish assemblages of high commercial and subsidence importance. Left: Turks and Caicos Islands, Right: Green Island Australia (photos: R. Unsworth).

its focus and became more realistic about the future. Governments, NGOs and communities should broaden and reprioritise strategies to protect tropical marine resources and look towards the concept of future reefs and alternative ecosystems that are also in trouble but are not beyond saving.

Broadening and rethinking conservation priorities

Poverty, over-population, coastal squeeze — the loss of intertidal habitat due to coastal construction — and coastal infrastructure are placing more and more pressure on tropical marine resources. It is unfortunate that the focus of tropical marine conservation is largely on coral reefs, because other systems, such as seagrasses, are as important. Seagrass meadows support productive fisheries and are a largely underappreciated resource for many people [21]. Furthermore, as the productivity of coral reefs decreases, there is more need for other habitats to absorb the fishing pressure on reefs. This means that we need to broaden our focus to an increasingly ecosystem-based approach that includes seagrass meadows.

There are widespread concerns for all biota in an era of rapid change, and in fact coral-reef loss may impact seagrass meadows in some localities [22]. There is also evidence that shallow water seagrasses can 'burn' at higher temperatures and be negatively affected by rising sea levels [23,24]. But overall, seagrasses are arguably somewhat better placed to deal with the stressors of high temperature, ocean acidification and sometimes to a lesser extent sea level rise [23,25]. This is because most seagrass species over most of their range are not yet close to their thermal maxima and because it is unlikely that rising seawater acidity will negatively impact their productivity.

In the tropical seascape, it is common for seagrass meadows to remain productive as corals rapidly change state. While doing so seagrass may actually support reef health [2], for instance by small-scale buffering of ocean acidification [26]. In addition, many key herbivores on coral reefs use seagrass as an alternative grazing habitat, so protecting fisheries on seagrass meadows adds to the functional role of coral-reef fish assemblages. This means that conservation support for seagrass does not compete with but rather enhances coral reef conservation efforts.

It is also important to consider which conservation initiatives could be beneficial to several components of the seascape, even though it might not be the most effective measure for one specific ecosystem per se. For example, reducing land-based pollution will have positive impacts on seagrass meadows and coral reefs, as well as other adjacent habitats. It is thus important to consider and argue for the cumulative benefits to the seascape. Depending on the in-water conditions, improving water quality might be the most important action for seagrass, an action that would also be very beneficial to other systems. Importantly we need to prioritize actions to ecosystems that result in improved ecosystem services.

In a changing climate, are fisheries moving towards seagrass?

Seagrasses provide global support for fisheries [1], including the direct provision of fishery grounds [21] (Figure 2). We hypothesise that this role for seagrass meadows will expand rapidly — and has potentially already done so — as coral reefs continue to degrade. There is growing evidence that, as coral reefs degrade, their ecosystem service value declines, particularly in terms of fisheries resources [8], especially as they lose their three-dimensional complexity [27]. As hard corals become replaced by alternative dominant groups (e.g. corallimorphs, soft corals and sponges) and reef accretion decreases, fishers will need to look elsewhere for resources. Seagrass ecosystems are one such alternative fisheries habitat that provide extensive, often easily accessible shallow-water fishing grounds [21]. When healthy, these seagrass systems contain an abundance of productive fish and invertebrate fauna [28] and even with limited gear it is often possible to catch fish and invertebrates in seagrass meadows.

In countries such as Indonesia, Sri Lanka, Tanzania and the Philippines, there is extensive evidence of high intensity seagrass fishing effort. Many of these localities are now heavily degraded reefs. In parts of Indonesia where reef fisheries have rapidly

declined, fishers target seagrass meadows [29]. There is also evidence of fishers rapidly working their way down the food chain becoming more dependent on species that were once considered highly unappealing, which demonstrates unsustainable pressure on the seagrass resources available. Similar patterns are also being observed in the Philippines. In the Indo-Pacific region, seagrasses compared to mangrove and coral reefs have been shown to be the most visited fishing grounds providing highest community benefits [30,31]. Increasing reliance on seagrass meadows as a dominant fishery habitat is leading to the widespread use of ever more efficient and exploitative fishing techniques, such as static fish fences [29], that lead to increased degradation of the food web.

Tropical marine and fisheries management is mostly focused on the needs of biodiversity protection for species of conservation concern, such as hard corals. The needs of coastal communities and their livelihoods receive only limited consideration, as do the threats of unsustainable fishing practice on other supporting habitats. But biodiversity and human livelihoods are not mutually exclusive [32]. As we enter an era dominated by more and more degraded reefs, we risk exacerbating the long-term failures of most tropical marine fisheries management by chasing an unachievable goal of coral reef conservation for ecosystem service provision.

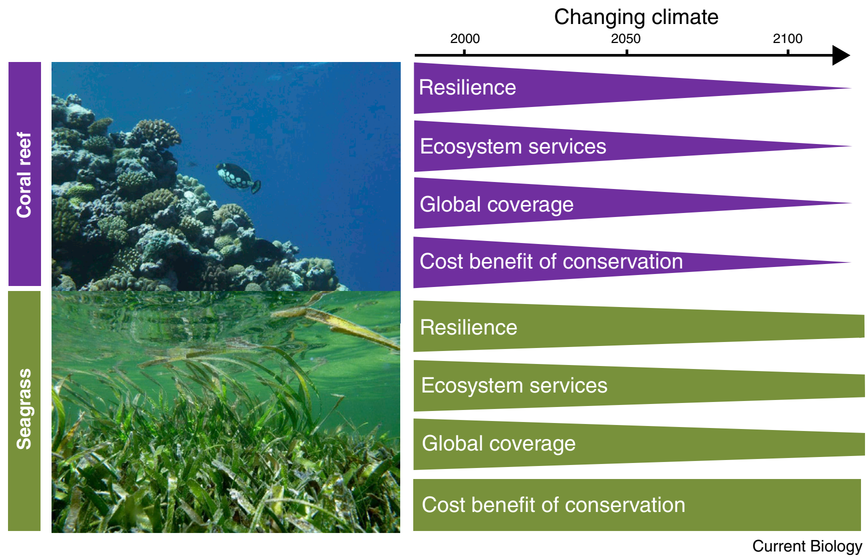

Figure 3. A changing climate for seagrass and coral reef.
Predicted changing resilience, ecosystem service provision, global coverage and cost-benefit of conservation (the benefits of conservation action summed, and then the costs associated with taking that action subtracted) for seagrass and coral reef ecosystems throughout the 21st century as a consequence of a changing climate. With declining reef three-dimensional structure and increasing record-breaking marine heatwave events, by the 2040s it is expected that between 70 and 90% of all coral reefs will have been lost [9]. By this time many seagrass meadows will also be negatively impacted by a changing climate, but these will be a small fraction of the global extent of seagrass (and a small proportion of those in tropical seas). Therefore, seagrass meadows will continue to provide ecosystem services and the cost–benefit of seagrass conservation will remain relatively high (photos: R. Unsworth).

The case for seagrass conservation

Conservation funding for tropical seagrass meadows is highly limited and seagrass research effort is minimal compared to other ecosystems, such as coral reefs and mangroves. In addition, in many parts of the world, governance and management of seagrass ecosystems is virtually absent. Seagrass conservation needs to be improved in order to not only increase seagrass viability but also to be prepared for the increasing reliance of fishers on these habitats. It is no longer sufficient for Marine Protected Area management plans to include seagrass as a 'tick box exercise', if that; instead, seagrass management needs to be included strategically using best-practice science to enhance fisheries productivity. In many parts of the world, the main problem for coastal ecosystems is catchment degradation (e.g. from loss of river vegetation, deforestation) and as such conservation of seagrass does not always need to be the focus. Ridge-to-reef conservation programmes can target wider-scale issues of catchment degradation and poor water quality and act as a platform for broader initiatives that include seagrass.

Seagrass meadows are experiencing increasing stress from local and regional impacts associated with degraded water quality, physical disturbance and the breakdown of food webs [4,5]. Global loss of seagrass has been taking place fast and on a large-scale [5]. But the drivers of seagrass loss are largely manageable and threats can be reduced with targeted efforts [33]. Seagrass restoration is increasingly successful [34], and a growing number of examples of catchment management lead to long-term seagrass recovery (Figure 3) [35]. Although seagrass restoration is expensive and historically many large projects have failed, the last decade has seen a step change in the restoration techniques being used, and as a result there are now many examples of successful projects conducted at viable cost [34]. This includes recent tropical seagrass restoration taking a multi-species approach [36], and in some circumstances restoration can now be conducted very cheaply through the large-scale dispersal of seeds [37]. Regardless, the most efficient and feasible conservation strategy is to preserve widespread productive seagrass meadows rather than having to rebuild or recreate them.

Humanity cannot afford to allow the integrity of yet another marine ecosystem to be compromised by short sighted management of our planetary resources. Maintaining essential ecosystem services is critical. The time is right for major conservation donors, government

regulators and conservation stakeholders to reprioritise their efforts to consider where ecosystem services now and in the future will arise. In fact, there is growing evidence for how fisheries management regimes globally need to respond to changing climate and develop adaptive policy targets [38].

There are some coral reef conservation 'bright spots' that indicate the potential for some coral reef survival [20]. But in order for our tropical seas to continue to be able to support fisheries and people we urgently need to focus on protecting ecosystems and biodiversity that provide the most critical ecosystem services while having the capacity to remain intact in a future climate. Seagrass meadows are one of those ecosystems and their conservation is paramount for the continued livelihoods and food security of many hundreds of millions of people. The time is right for global conservation efforts to conserve seagrass ecosystems.

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